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Box PATENT APPLICATION
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 Washington, D.C. 20231

Date: November 27, 2000

Docket No 30012740-02

Sir:

Transmitted herewith for filing is the patent application of

Inventor(s): Yuji Hiraoka
 Takeo Endo
 Michio Matsumoto

For: Liquid Electrophotographic Developing Apparatus

I hereby certify that this paper is being deposited with the United States Postal Service as Express Mail in an envelope addressed to: Assistant Commissioner For Patents, Washington, D.C. 20231, on this date.

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Enclosed are:

- ☒ 7 pages of specification, 3 pages of claims and an abstract.
- ☒ Certified Copy of Taiwanese Appln. No. 089103995 filed March 6, 2000
- ☒ an executed oath or declaration, with power of attorney.
- ☐ an unexecuted oath or declaration, with power of attorney.
- ☐ sheet(s) of informal drawing(s).
- ☒ 3 sheet(s) of formal drawings(s).
- ☐ Information Disclosure Statement, Form 1449 and cited references
- ☐ Assignment(s) of the invention to
- ☐ Assignment Form Cover Sheet.
- ☐ A check in the amount of \$ to cover the fee for recording the assignment(s) is enclosed.
- ☐ Associate power of attorney.

Fee Calculation For Claims As Filed

| | | | | | | | |
|----------------------------|----|---|------|---|---|----------|--------|
| a) Basic Fee | | | | | | \$ | 710.00 |
| b) Independent Claims | 2 | - | 3 = | 2 | X | \$80.00 | = \$ |
| c) Total Claims | 10 | - | 20 = | 6 | X | \$18.00 | = \$ |
| d) Fee for Multiple Claims | | | | | X | \$270.00 | = \$ |

Total Filing Fee \$ 710.00

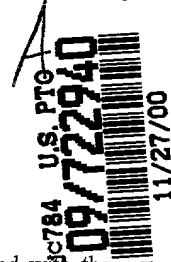
- ☒ Applicant claims small entity status (37 CFR 1.27) reducing Filing Fee by half to \$ 355.00
- ☒ Check No. 123472 in the amount of \$ 355.00 to cover the filing fee is enclosed
- ☐ Charge \$ to Deposit Account No. 19-3140.
- ☐ Other .
- ☒ The Commissioner is hereby authorized to charge any additional fees which may be required to this application under 37 C.F.R. §§1.16-1.17, or credit any overpayment, to Deposit Account No. 19-3140. Should no proper payment be enclosed herewith, as by a check being in the wrong amount, unsigned, post-dated, otherwise improper or informal or even entirely missing, the Commissioner is authorized to charge the unpaid amount to Deposit Account No. 19-3140. Two duplicate copies of this sheet are enclosed.

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LIQUID ELECTROPHOTOGRAPHIC DEVELOPING APPARATUS

FIELD OF THE INVENTION

The present invention relates to an electrophotographic developing apparatus for a
5 copier or a printer, and more particularly, to a liquid electrophotographic developing
apparatus in which leakage of liquid developers is prevented.

BACKGROUND OF THE INVENTION

Conventional liquid electrophotographic developing apparatuses bring a liquid
10 developer into contact with an electrostatic latent image to be developed in any of several
different ways. According to one method, the surface of a photoreceptor or other
member carrying an electrostatic latent image is merely dipped into a bath of a liquid
developer to develop the electrostatic latent image.

In another method, such as described in USP No. 5,017,968, a liquid developer is
15 supplied to a head which extends across the width of a member bearing an electrostatic
latent image and the liquid developer is supplied through one channel in the head to a slot
opening where it is brought into contact with the surface of the image-bearing member.
The liquid developer is then withdrawn from the slot opening through another channel in
the developing head.

20 In a further liquid developing arrangement, as shown in USP No. 5,708,937, a
rotating cylinder is coated with a liquid developer at a supply point and carries the
developer into contact with the image-bearing member to develop the image. Other
apparatuses for supplying a liquid developer to an image-bearing member through a slot

extending across the width of the member are disclosed in USP Nos. 5,708,936, 5,737,672 and 5,765,078.

Such apparatuses for supplying a liquid developer to an image-bearing member have certain disadvantages including generation of odors resulting from vaporization of the liquid developer within the region of the developing unit, difficulties in reproducing colored images with successive developers of different colors in a single pass of the image-bearing member, and excessive size and cost of the developing units.

On the other hand, USP Nos. 5,358,659, 5,567,564 and 5,667,716 disclose methods of preparing magnetic liquid developers while USP No. 4,797,013 discloses the use of ferrofluids retained by magnets in gaps between moving members to seal lubricants in bearing arrangements. USP No. 4,645,960 discloses a ferrofluid bearing. USP No. 5,461,466 discloses a dripless seal for a liquid toner cartridge by which the cartridge is closed when not in use.

SUMMARY OF THE INVENTION

An object of the present invention is to set forth a liquid developing apparatus of electrostatic latent images that overcomes disadvantages of the prior art.

Another object of the present invention is to provide a liquid developing apparatus that minimizes emission of vapor from a liquid developer into the surrounding atmosphere.

A further object of the present invention is to provide a liquid developing apparatus that facilitates multicolor development of electrostatic images in a single pass of an image-bearing member.

An additional object of the present invention is to provide a compact and inexpensive liquid developing apparatus.

According to one aspect of the present invention, a liquid developing apparatus comprises:

5 a developing unit, having an elongated opening disposed adjacent to a moving image-bearing surface of a photoreceptor, for converting an electrostatic latent image into a toner image; and

10 an air duct, provided around the elongated opening of the developing unit, containing air flow therein having a predetermined air pressure to hold a liquid developer within a space between the developing unit and the image-bearing surface while permitting toner particles in the liquid developer deposited on the image-bearing surface to be retained by the image-bearing surface and allowing volatile solvent in the developer to be vaporized into the surrounding atmosphere.

15 According to another aspect of the present invention, a liquid developing apparatus comprises:

20 a plurality of developing units, each having an elongated opening disposed adjacent to a moving image-bearing surface of a photoreceptor which passes adjacent to the plurality of developing units in succession, for converting an electrostatic latent image into a toner image, each of the plurality of developing units containing a liquid developer of a different color; and

 a plurality of air ducts, each provided around the elongated opening of the developing unit, containing air flow therein having a predetermined air pressure, for causing the liquid developer to be retained adjacent to the elongated opening in the

developing unit while depositing toner particles on an electrostatic latent image on the image-bearing surface of the photoreceptor as the photoreceptor moves adjacent to the elongated opening.

5

BRIEF DESCRIPTION OF THE DRAWINGS

These and other objects, features and advantages of the present invention will become apparent to those skilled in the art upon consideration of the following description of the preferred embodiments of the present invention taken in conjunction with the accompanying drawings, in which:

10

Fig. 1 is a sectional view of a liquid developing apparatus according to an embodiment of the present invention;

Fig. 2 is a plan view showing an elongated developing head of the liquid developing apparatus in Fig. 1; and

15

Fig. 3 is a view four liquid developing apparatuses used in an electrophotographic system.

DETAILED DESCRIPTION

In a preferred embodiment of the present invention illustrated in Figs. 1-3, an electrophotographic system 10 includes a belt-type photoreceptor 12 conveyed in the direction of the arrows in an endless loop around two spaced rollers 14 and 16. In order to produce a multicolor image, four printing stations 18, 20, 22 and 24 are disposed adjacent to the photoreceptor along a straight path of the photoreceptor belt. Each printing station includes a charging unit 26, an exposing unit 28 and a developing unit 30

and all of the printing stations are identical except that the four developing units 30 contain different colored liquid developers, for example, yellow (Y), magenta (M), cyan (C) and black (K).

As the photoreceptor 12 is driven past each printing station in its loop-shaped path, it is first charged by the charging unit 26 and then exposed by the exposure unit 28 to produce an electrostatic latent image appropriate for the particular color to be applied by that printing station and the image is then developed by the developing unit 30 with the correspondingly colored liquid developer. After all of the colored images have been printed, a medium 34 such as paper sheet or transparency is brought into contact with the surface bearing the colored image at a transfer station 36 so that the colored image is transferred to the medium 34 and the surface of the photoreceptor is thereafter cleaned at a cleaning station 40 in preparation for formation of the next colored image.

As known from Fig. 1, a liquid developer 42 in a reservoir 44 is supplied to the surface of the photoreceptor 12 between closely spaced parallel plates 46 and 48 which form a narrow gap 50 with the photoreceptor surface, permitting the liquid developer to come into contact with the surface during its motion in the direction of the arrow for a sufficient distance 52 to permit toner particles to be withdrawn from the developer liquid and adhered to the charged regions of the surface of the photoreceptor to produce a toner image. A flow control mechanism for maintaining the developer at a proper constant pressure is provided between the parallel plates 46 and 48, and in this embodiment, it comprises a flow pressure sensor 54 and a control valve 56.

An air duct 58 is provided around the parallel plates 46 and 48, and an air flow therein comes from a pump 60, having an air pressure controlled by an air pressure

control mechanism comprising an air pressure sensor 62 and a flow control valve 64. According to the present invention, preferably, solvent for the developer is innocuous and volatile liquid such as water, alcohol and other organic solvents. As a result, toner particles in the liquid developer can be adhered to an electrostatic latent image on the surface of the photoreceptor 12 by adjusting pressures of the liquid developer 42 and air flow, while any developer material which is not bound to the photoreceptor surface is retained within the developing unit 30, thus preventing escape of other components of the liquid developer. In this way, both liquid and solid developer components are prevented from being transported on the surface of the photoreceptor to contaminate subsequent images of other colors.

In order to insure a continuous supply of toner particles to the photoreceptor surface, the liquid developer 42 may be circulated from the reservoir 44 to the gap 50 by a conventional pumping arrangement.

On the other hand, the charge on the toner particles in the liquid developer 42 should be of the correct polarity and strong enough to be retained on the surface of the photoreceptor by the electrostatic charges in the image. Such control of the polarity and magnitude of the charge on the toner particles can be effected in conventional ways known to those skilled in the art, and the details thereof are omitted.

The gap 50 and the gap 52 should be about the same size, preferably between about 0.1 mm and about 1 mm. The size of the gaps depends on the processing speed and should be decreased as the processing speed is increased.

With the apparatus described about, the developing units 18, 20, 22 and 24 can be both compact and inexpensive to manufacture. Moreover, the developing apparatus of

the present invention permits highly efficient one-pass multicolor processing because the adhering force between the toner particles and the electrostatic latent image can be controlled so as to be strong enough to overcome any tendency of the toner particles to be dislodged from the photoreceptor by the motion of the photoreceptor surface.

5 While the present invention has been described in conjunction with preferred embodiments thereof, it is evident that many alternatives, modifications and variations will be apparent to those skilled in the art. Accordingly, it is intended to embrace all such alternatives, modifications and variations that fall within the spirit and scope thereof as set forth in the appended claims.

10

What is claimed is:

1. A liquid electrophotographic developing apparatus, comprising:

a developing unit, having an elongated opening disposed adjacent to a moving
5 image-bearing surface of a photoreceptor, for converting an electrostatic latent image into
a toner image; and

an air duct, provided around the elongated opening of the developing unit,
containing air flow therein having a predetermined air pressure to hold a liquid developer
within a space between the developing unit and the image-bearing surface while
10 permitting toner particles in the liquid developer deposited on the image-bearing surface
to be retained by the image-bearing surface and allowing volatile solvent in the developer
to be vaporized into the surrounding atmosphere.

2. The liquid electrophotographic developing apparatus according to claim 1,
15 wherein the air duct is provided with air pressure control means for maintaining the air
flow at a predetermined pressure.

3. The liquid electrophotographic developing apparatus according to claim 2,
wherein the air pressure control means comprises an air pressure sensor and a flow
20 control valve.

4. The liquid electrophotographic developing apparatus according to claim 1, wherein the developing unit is provided with flow control means for controlling flow of the liquid developer.

5. The liquid electrophotographic developing apparatus according to claim 4, wherein the flow control means comprises a flow pressure sensor and a control valve.

6. A liquid electrophotographic developing apparatus, comprising:

a plurality of developing units, each having an elongated opening disposed adjacent to a moving image-bearing surface of a photoreceptor which passes adjacent to the plurality of developing units in succession, for converting an electrostatic latent image into a toner image, each of the plurality of developing units containing a liquid developer of a different color; and

a plurality of air ducts, each provided around the elongated opening of the developing unit, containing air flow therein having a predetermined air pressure, for causing the liquid developer to be retained adjacent to the elongated opening in the developing unit while depositing toner particles on an electrostatic latent image on the image-bearing surface of the photoreceptor as the photoreceptor moves adjacent to the elongated opening.

7. The liquid electrophotographic developing apparatus according to claim 6, wherein the air duct is provided with air pressure control means for maintaining the air flow at a predetermined pressure.

8. The liquid electrophotographic developing apparatus according to claim 7, wherein the air pressure control means comprises an air pressure sensor and a flow control valve.

5

9. The liquid electrophotographic developing apparatus according to claim 6, wherein the developing unit is provided with flow control means for controlling flow of the liquid developer.

10. The liquid electrophotographic developing apparatus according to claim 9, wherein the flow control means comprises a flow pressure sensor and a control valve.

ABSTRACT OF THE DISCLOSURE

The present invention discloses a liquid electrophotographic developing apparatus including a developing unit and an air duct. The developing unit has an elongated opening disposed adjacent to a moving image-bearing surface of a photoreceptor, and it is used for converting an electrostatic latent image into a toner image. The air duct is provided around the elongated opening of the developing unit, and air flow therein has a predetermined air pressure to hold a liquid developer within a space between the developing unit and the image-bearing surface while permitting toner particles in the liquid developer deposited on the image-bearing surface to be retained by the image-bearing surface and allowing volatile solvent in the developer to be vaporized into the surrounding atmosphere.

Figure 1

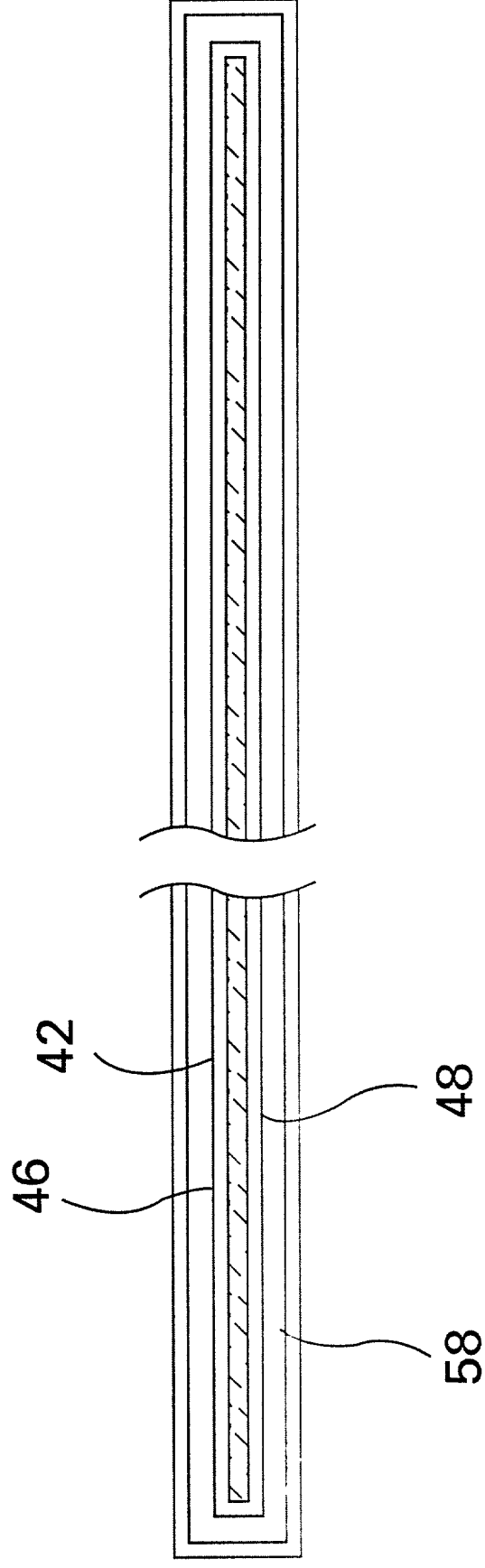


Figure 2

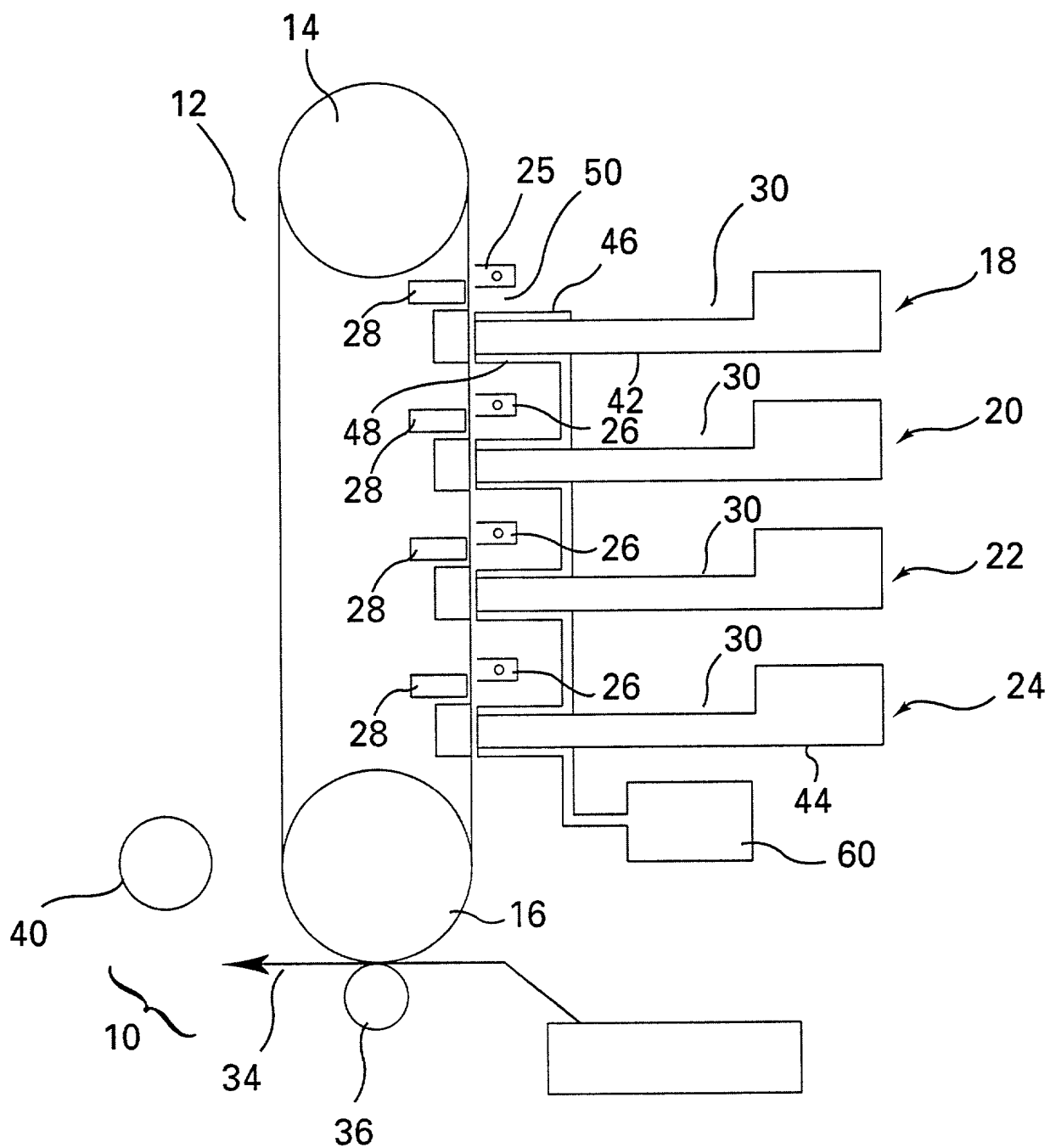


Figure 3

DECLARATION AND POWER OF ATTORNEY

This declaration is of the following type:

- ☒ original ☐ divisional ☐ design ☐ continuation
☐ supplemental ☐ continuation-in-part ☐ national stage of PCT

As a below named inventor, I hereby declare that:

My residence, post office address, and citizenship are as stated below next to my name.

I believe I am the original, first, and sole inventor (if only one name is listed below) or an original, first, and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled Liquid Electrophotographic Developing Apparatus the specification of which:

- ☒ is attached hereto; or
☐ was filed on _____ as United States Application Serial Number or PCT International Application Number _____ and was amended on _____ (if applicable).

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information, which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, § 1.56(a).

I hereby claim foreign priority benefits under Title 35, United States Code, § 119(a)–(d) or § 365(b) of any foreign application(s) for patent or inventor's certificate, or § 365(a) of any PCT international application which designated at least one country other than the United States of America, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or any PCT international application having a filing date before that of the application on which priority is claimed.

| Prior Foreign Application Number | Country | Foreign Filing Date (MM/DD/YYYY) | Priority Not Claimed | Certified Copy Attached? | |
|----------------------------------|---------|-------------------------------------|--------------------------|-------------------------------------|--------------------------|
| | | | | Yes | No |
| 089103995 | Taiwan | 03/06/2000 | <input type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/> |
| | | | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

I hereby claim the benefit under Title 35, United States Code, § 119(e) of United States provisional application(s) listed below.

| Application Serial Number | Filing Date (MM/DD/YYYY) |
|---------------------------|--------------------------|
| | |
| | |

I hereby claim the benefit under Title 35, United States Code, § 120 of any United States application(s), or § 365(c) or any PCT international application designating the United States of America, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of Title 35, United States Code, § 112, I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, § 1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application.

| U.S. or PCT Parent Application Serial Number | Parent Filing Date (MM/DD/YYYY) | Parent Patent Number (if applicable) |
|-------------------------------------------------|------------------------------------|-----------------------------------------|
| | | |
| | | |

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PATENT

As a named inventor, I hereby appoint the following registered practitioners to prosecute this application and transact all business in the United States Patent and Trademark Office connected therewith:

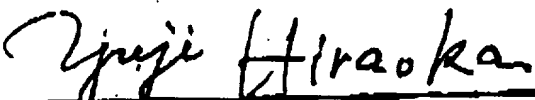

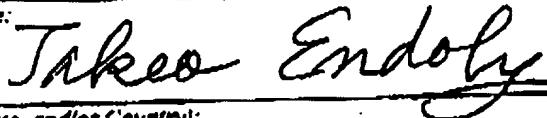
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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

| | |
|----------------------------------------------------------------------------------------------------------------------------|-----------------------------------|
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